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Status of Lithium-Ion Cell Certification at EaglePicher Technologies, LLC

By Jeff Dermott

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Agenda

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- Lithium-Ion Timeline at EaglePicher
- Engineering Model Cell Data
- EaglePicher Cell Certification Plan
- Summary

EP Lithium-Ion Facility

- Fully funded by EaglePicher
- Designed for large cell construction
- Anode and cathode mixing rooms are separate and sealed
- Dedicated air handling for critical processes
- Coating room designed as class 10,000 cleanroom
- Cell assembly room: class 10,000 certified, -40°C dew point
- Semi-automated process control

Timeline of Lithium-Ion Activities

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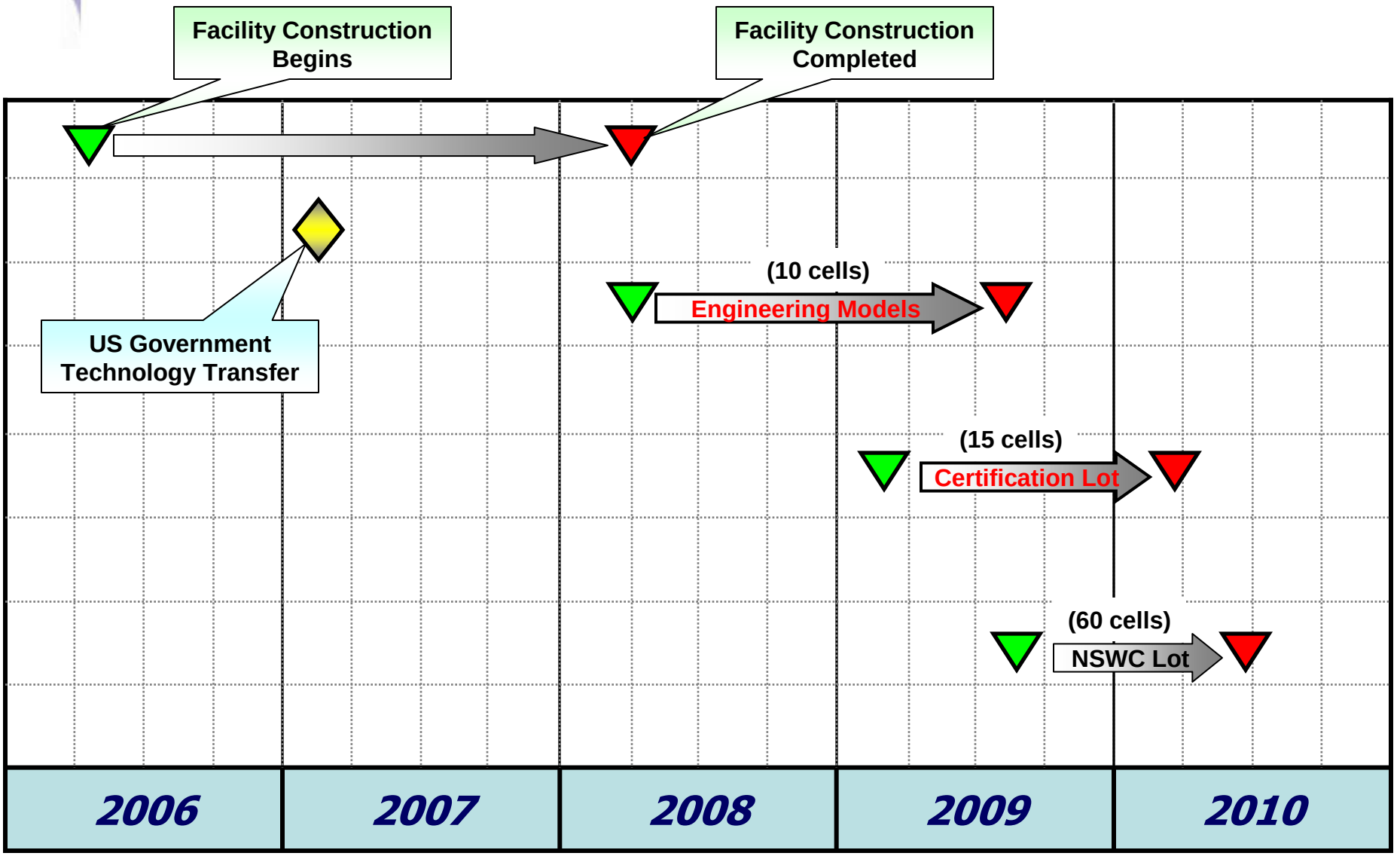

Technology Transfer, 62AH Cell

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- $LiCoO_2$ Chemistry
  - 52AH Nameplate (using 5/6 rule)
- Hermetically sealed container
  - Material: SS
  - LASER weld construction
  - Crimped terminal design
- Terminals
  - Positive: Aluminum, Nickel plated
  - Negative: Copper, Gold plated
- Flat-plate electrode design
- Physical Properties:
  - 1955 grams
  - 7.9” Tall x 3.2” Wide x 2.22” Thick
- Specific Energy = 125 Whr/kg
- Energy Density = 266 Whr/L

Engineering Model Cells

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- Used for facility run-in
- Cells E2 and E3 performing LEO cycling at 40%DOD
  - LEO cycling continues
  - Accumulated cycle count of 4,821 as of 01-Nov-2009
- Cells E8 and E9 used for variety of characterization tests
  - Temperature characterization tests at C, C/2 & C/5 rates
  - 7-Day Charge Retention
  - Cell DC Resistance Measurement
  - Planned for Vibration & DOT with DPA in early December
- Cell E10 being used for various engineering tests
  - Planned for Vibration & DOT with DPA (w/E8 & E9)

E2, E3 LEO Life Testing

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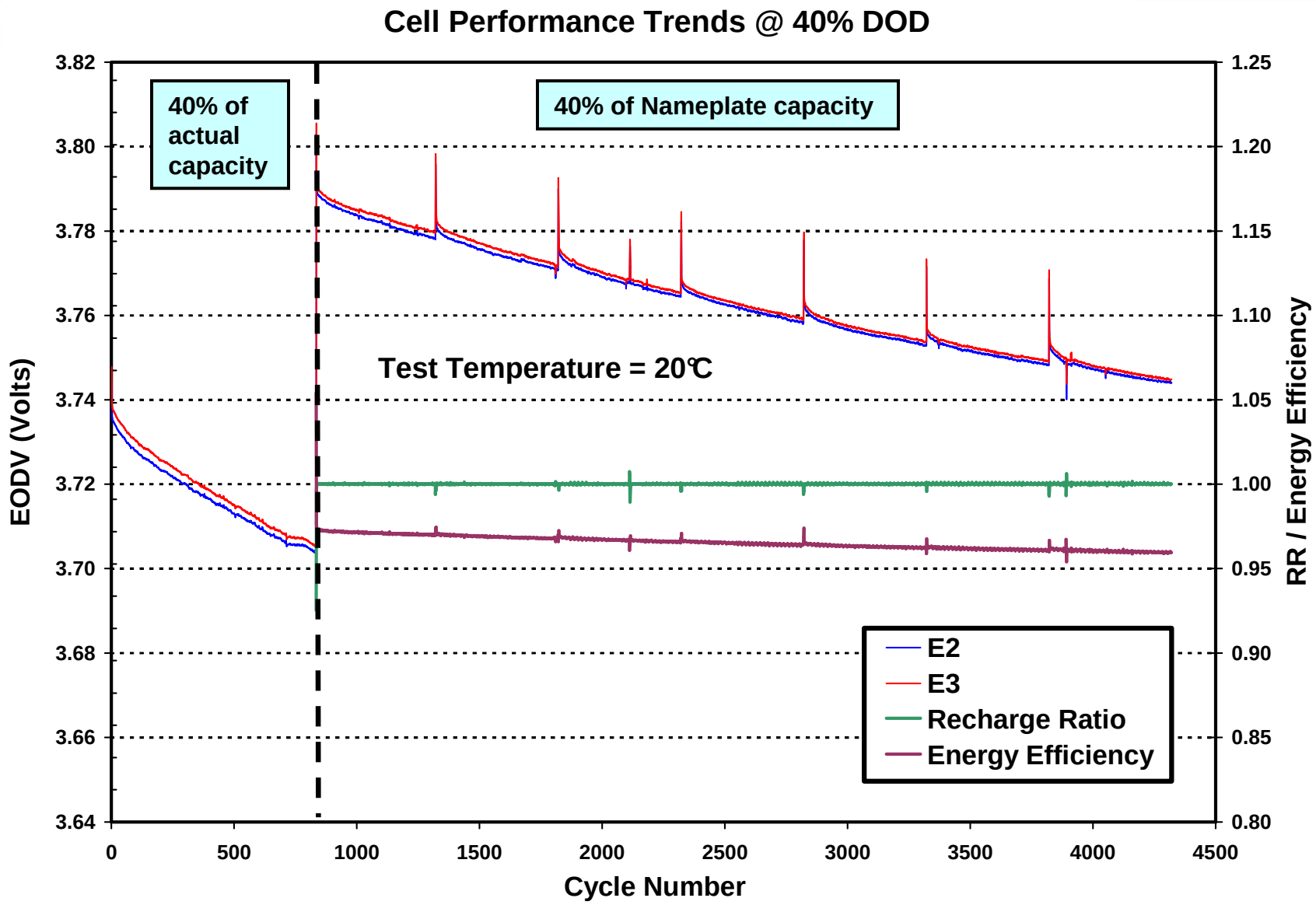

E2 LEO Life Testing

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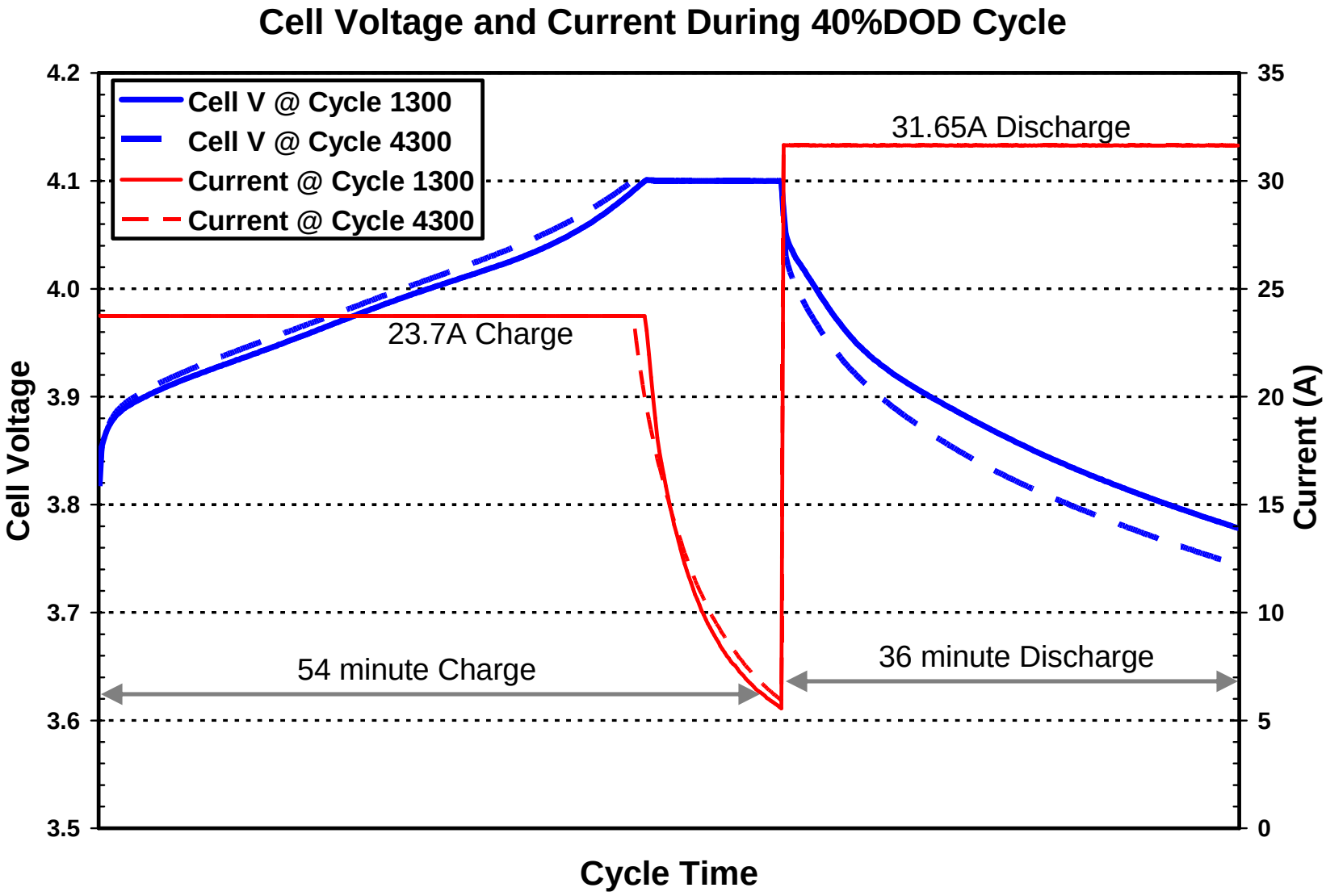

E2, E3 LEO Life Testing

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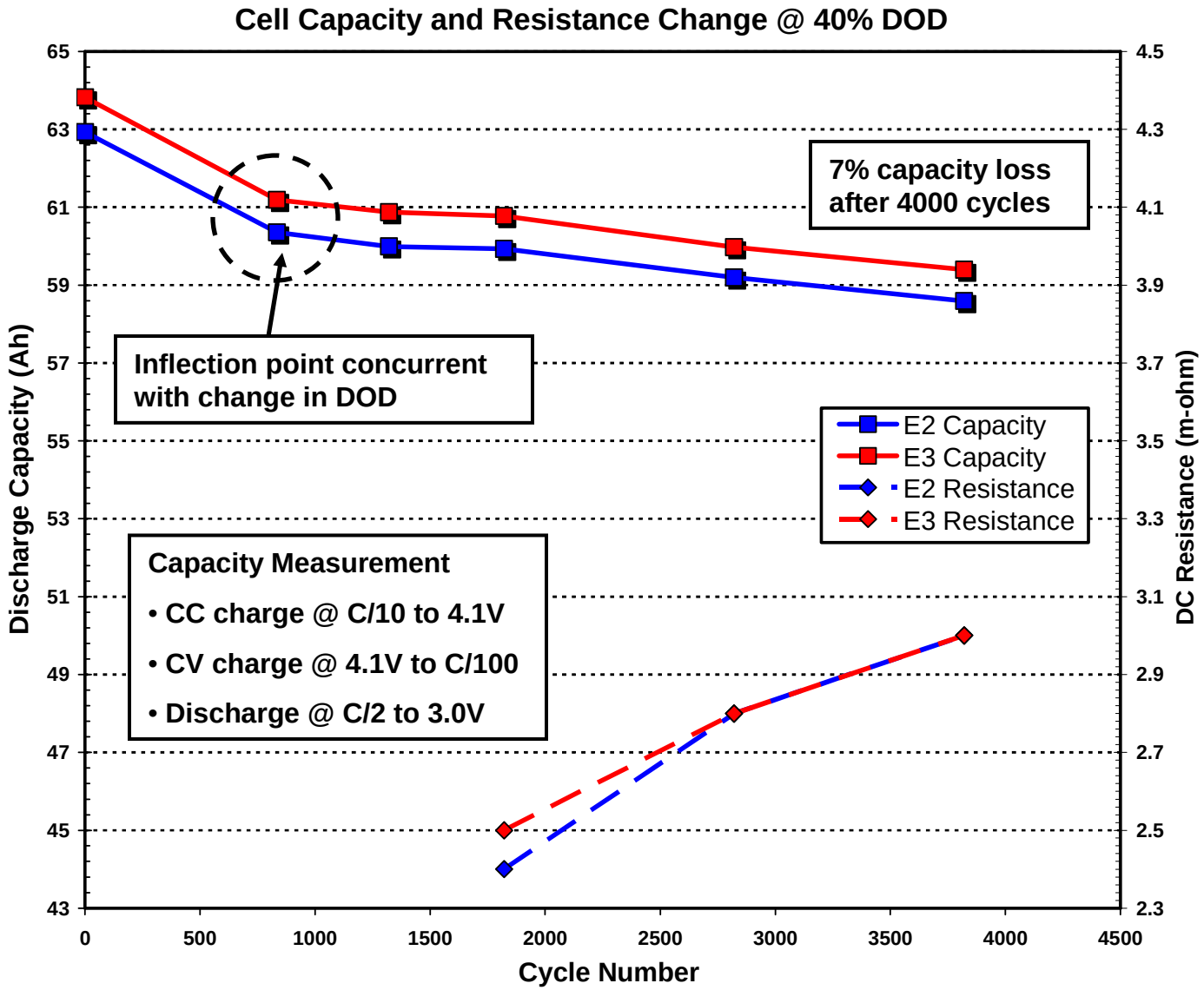

E8, E9, E10 Capacity Testing

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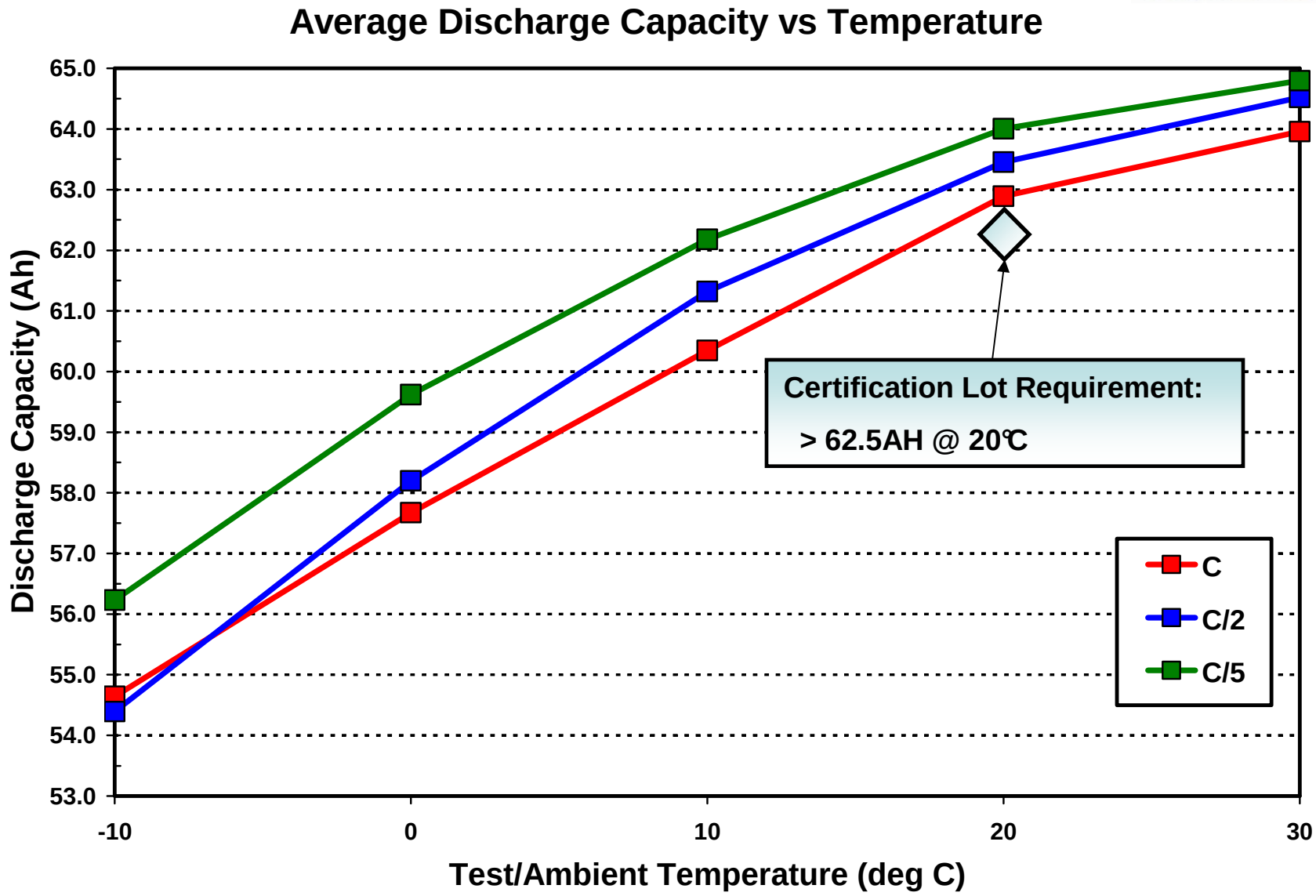

E8, E9, E10 Charge Retention Test

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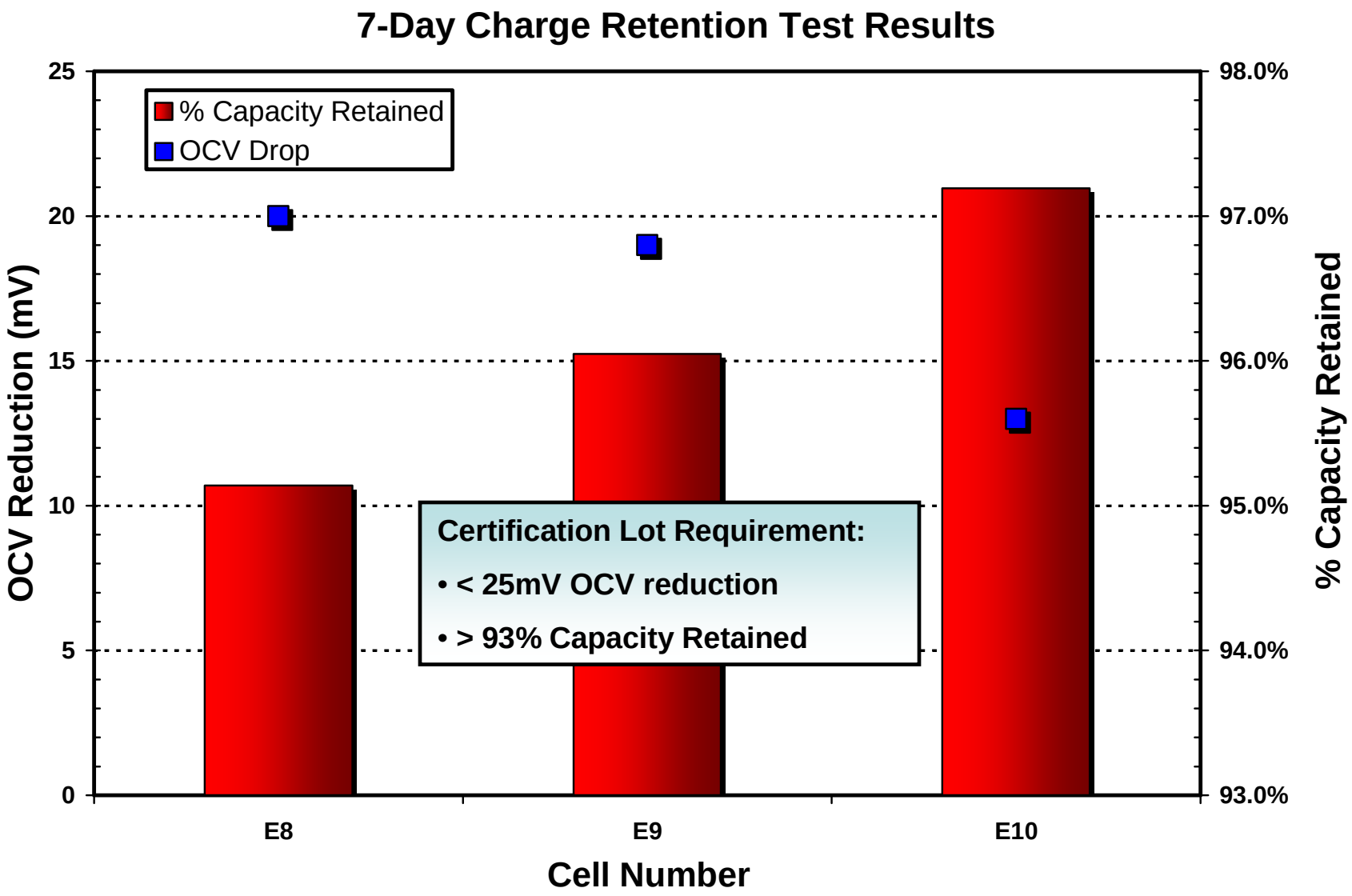

E8, E9, E10 DC Resistance Test

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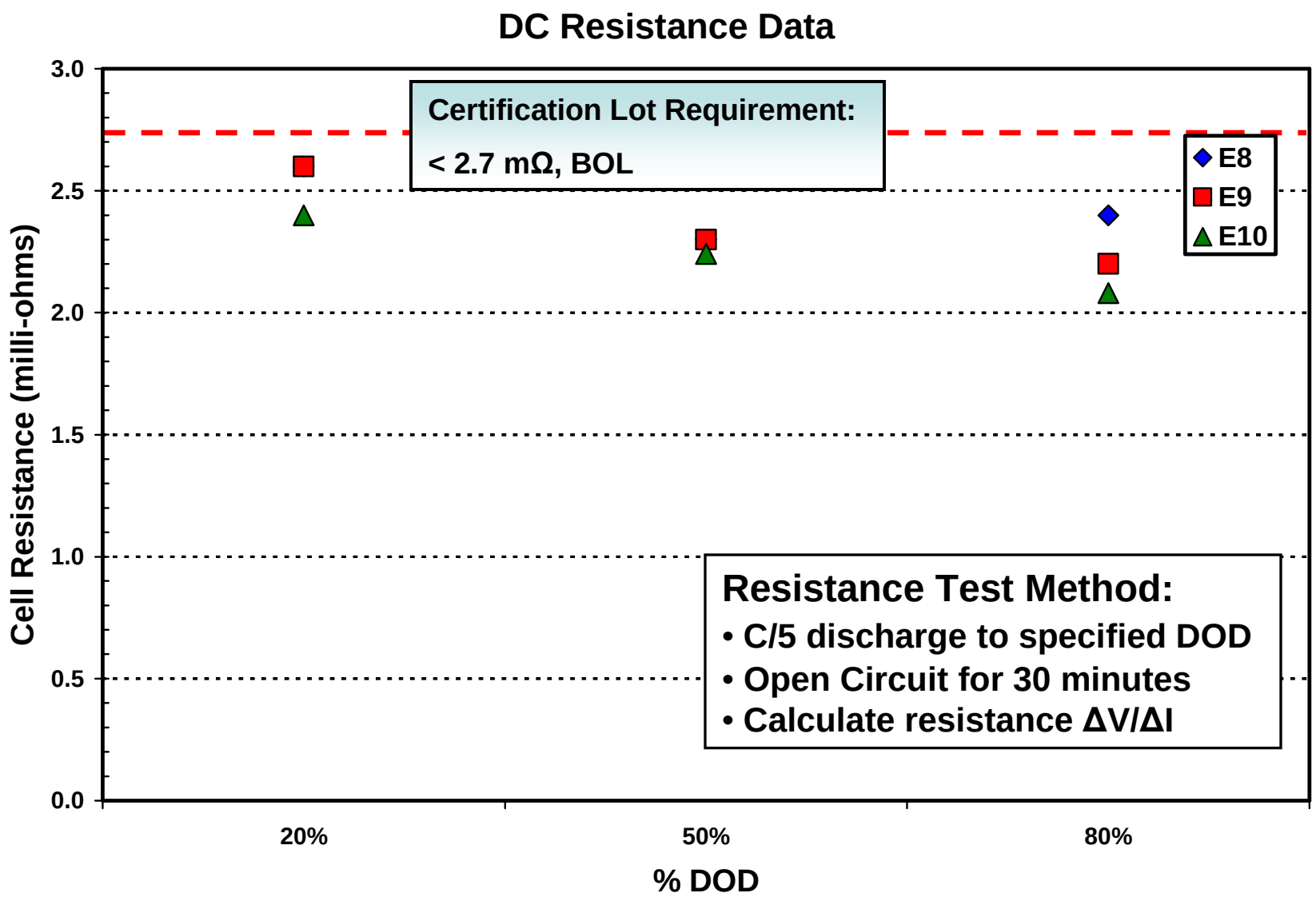

Certification Cells

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- Cell lot will consist of 15 EPT, 5 USG Cells
- "Build to Print" qualified cell design
- Used to certify manufacturing capability at EaglePicher
- After activation and formation, lot will be subdivided
- Various tests will be performed in conjunction with USG supplied cells
- *Successful completion of testing finalizes technology transfer*

Certification Plan

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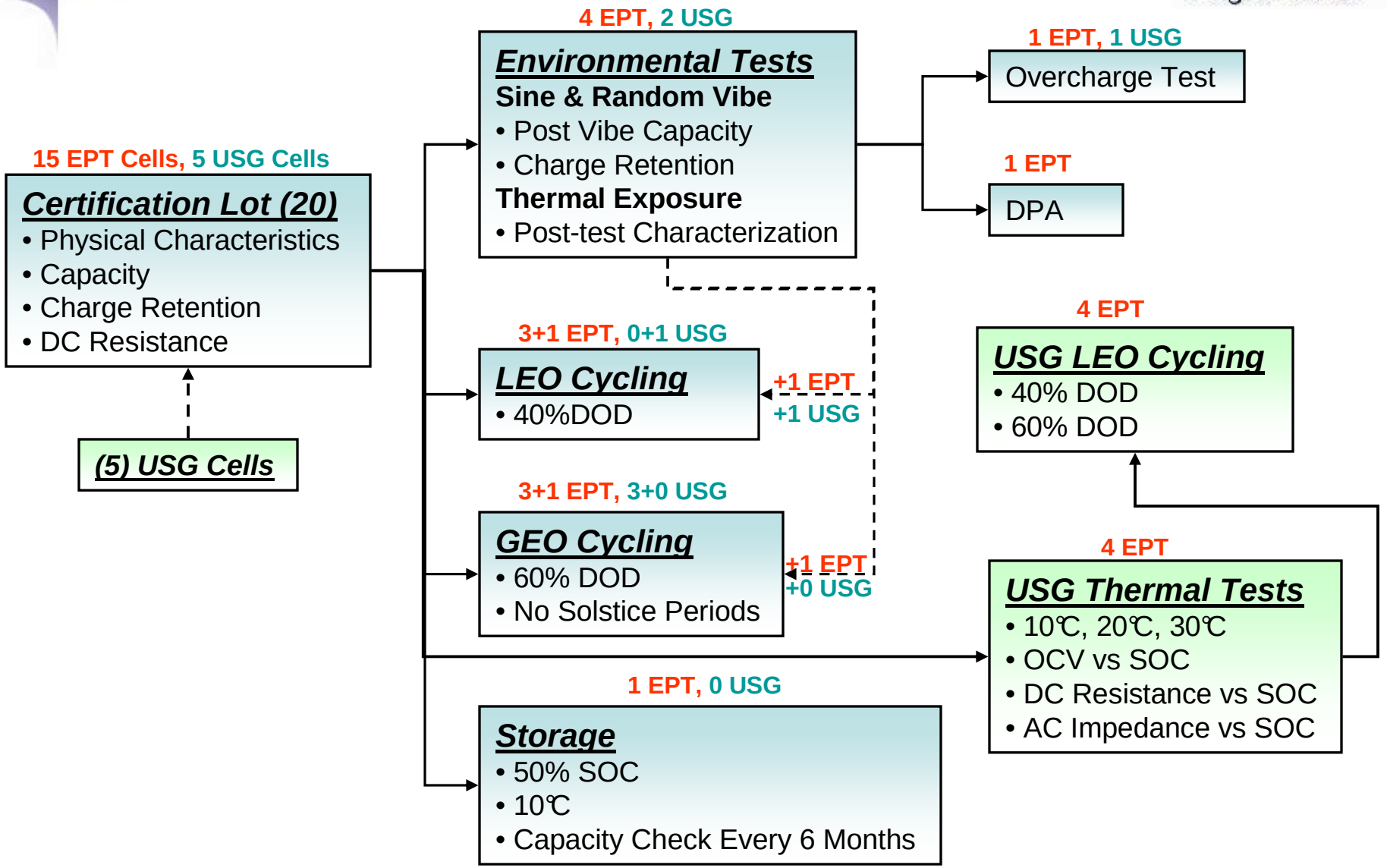

EPT Certification Tests

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- Capacity Tests, 20°C
  - Charge
    - CC @ C/10 to 4.1V
    - CV @ 4.1V to C/100
  - Discharge
    - C/2 and C/5 to 3.0V
  - Criteria: 62.5AH to 3.0V
- 7-day Charge Retention, 20°C
  - Charge
    - CC @ C/10 to 4.1V
    - CV @ 4.1V to C/100
  - Discharge
    - C/2 to 3.0V
  - Criteria: 25mV max drop / 93% retained capacity

EPT Certification Tests (Cont'd)

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- Vibration Tests
  - Charge to 100% SOC
  - Sine & Random Vibration
    - Discharge @ C/10
    - Monitor current and voltage
  - Post-test capacity, charge retention, DC resistance
- Thermal Exposure
  - Charge to 50% SOC
  - 2 temperature cycles, -10°C to 35°C
  - Post-test capacity, charge retention, DC resistance

Sine Vibration Levels	
Frequency Hz	**Acceleration g**
10.0	12.7 mm (displaced amplitude)
24.2	15
34.5	15
36.0	20
55.0	20
57.5	7
100.0	7
sweep rate: 2 octaves / min	

Random Vibration Levels	
Frequency Hz	**Power Spectral Density - g^2/Hz**
20	0.1
100	0.5
1000	0.5
2000	0.025
g_{rms} = 26.9	
duration: 3 min per axis	

EPT Certification Tests (Cont'd)

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- Overcharge Characterization @ 20°C
  - Charge @ C/10 to 3.7V
  - Discharge @ C/2 to 3.0V
  - Increment EOCV by 0.1V
  - Repeat discharge
  - Continue 0.1V increments to 5.1V or until cell fails
  - Characterize capacity and resistance at each EOCV increment
- DC Resistance
  - Discharge @ C/5 to specified DOD (20, 50, 80%)
  - Open circuit for 30 minutes
  - Calculate resistance $\Delta V/\Delta I$
  - Criteria: 2.7 mΩ max

EPT Certification Tests (Cont'd)

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- 40% DOD LEO Cycling at 20°C
- DOD based on Nameplate Capacity of 52AH
- Charge
  - CC @ 26A to 4.0V
  - CV @ 4.0V to 0.5A or 54 minutes total charge time
- Discharge @ 34.67A for 36 minutes
- Continue to a minimum of 30,000 cycles
- Measure capacity and DC resistance
  - @ 500 cycles
  - @ 1000 cycles
  - 1000 cycle increments thereafter

EPT Certification Tests (Cont'd)

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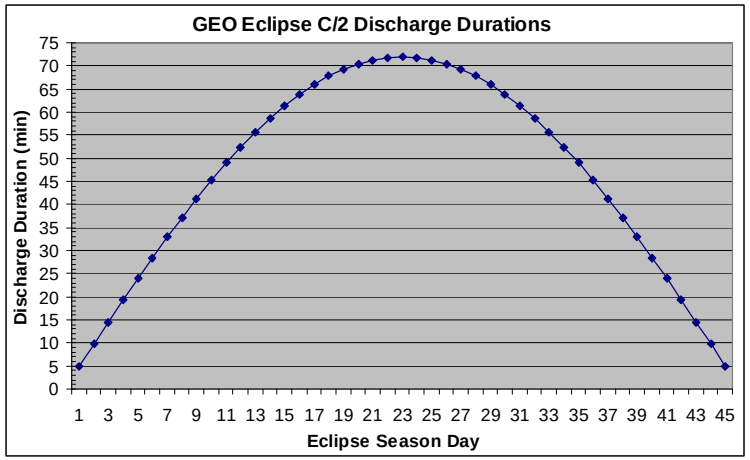
- 60% max DOD accelerated GEO cycling at 20°C
  - DOD based on Nameplate Capacity of 52AH
- 1 cycle per day
- 45 day eclipse season
- 2 day solstice season with cell at 100% SOC
- Charge
  - CC @ 2.6A to 4.0V
  - CV @ 4.0V to 0.5A
  - Open circuit until next discharge
- Discharge
  - Rate = 26A
  - Duration will vary during 45 day eclipse season (72 min. max)
- Continue to a minimum of 1,350 cycles
  - Measure Capacity & DC resistance after every 2 eclipse seasons



Summary

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- Performance of EM cells currently meeting expectations
- EPT will complete certification cell testing in January 2010
  - Finalizes facility certification for production of USG technology
- Life Tests will continue with EM and Certification cells
- Additional Li-Ion deliveries in 2010
  - Heritage cells to NSWC for industry testing
  - Large format cells for Aircraft starter applications
  - Coatings for Medical applications

Acknowledgements

- Eric Quee, EPT
- James Bond, EPT